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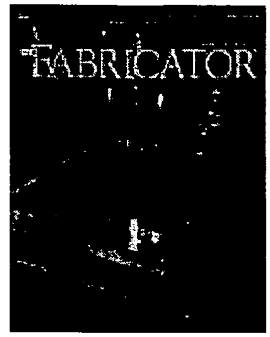

Laser Welding Medical Products

Understanding Material Considerations and Joint Design

By Gary Oberg, P.E.

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Because of the laser beam's size and controllability, laser welding is used for joining many medical product assemblies. The products range in size from tiny pacing leads to operating room surgical tools.

Because an Nd:YAG laser beam (1.06µ) can be focused down to approximately 25µ- (0.001-inch) diameter, it is often used to weld medical components, which frequently require small welds. The power can be distributed from a few hertz (Hz) to more than 1,000. This allows for good heat dissipation and a small heat-affected zone (HAZ).

A CO_2 laser powered at 10.6µ can also be used on 1-millimeter and thicker metal components. This laser can accomplish keyhole welding that yields a high aspect ratio (depth of weld to width).

Because most medical components are relatively small, this article focuses on Nd:YAG laser welding. However, some of the designs discussed can also be welded with a CO_2 laser.

Weld Area

Most medical product laser welds are accomplished by the fusion process, in which no filler metal is added. This leaves a metallurgically pure weld consisting of just the base metals. Filler metals can be used, but they add cost because of added handling and fixturing complexities.

Many medical products require the weld area to be free of weld spatter and to be both sealed and smooth so that the weld joint will not retain fluids. In addition, the welds must be easily cleaned.

A few designs must be hermetically sealed to a specific torr rating. Common examples include pacemaker cans and cans that seal magnetic and radioactive materials. These joints are typically welded in a glove box.

To weld many medical products, no special prepping is required other than standard cleaning and degreasing of cutting oils. Grease or oil should not be used for press fitting parts together because they can cause excessive spatter and pitting.

Material Considerations

The materials that are most frequently used for welding medical products are 316L and 302/304 stainless steels. 316L stainless steel is very corrosion-resistant to blood and thus makes a good choice.

A common mistake that some designers make is specifying 303 steel because it is readily available in bar stock form and has free-machining characteristics. Even though extremely shallow welds of 0.004 inch (0.1 millimeter) or less can be made on 303 steel, it is not recommended for welding medical products. 303 contains phosphorous and sulfur, which can cause crackling in the weld joint.

There is an increased demand to weld more exotic materials such as gold, platinum, tantalum, and nitinol. These materials appeal to designers because they are more flexible, radiopaque, and ductile than less-exotic metals.

In general, metals that have a high reflectivity and heat conductivity, such as gold and platinum, should be avoided. Efusivity (heat conductivity and reflectivity combined) makes coupling the beam into the base metals difficult, which in turn makes gaps more difficult to fill. The higher a metal's efusivity, the more important joint design becomes.

Joint Design

Often, joint design is the last consideration in the design process. The engineer typically shows up with a bag of parts and says, "weld 'em." Designers can box themselves into a corner by underestimating the difficulties of welding joints.

A bad joint design can make an easy weld difficult. Conversely, a good joint design can make a difficult material much easier to weld. Figure 1 shows an improved design for laser joint welding.

The tightness of the joint, or fit, is critical. A joint with gaps of more than 0.002 inch (0.05 millimeter) will result in spatter and aberrations.

When a gap is larger than 0.002 inch, the weld parameters begin to become difficult to optimize to achieve a consistent process. A CO2 laser operated in a continuous-wave (CW) mode is more tolerant of larger gaps and metal porosity than an Nd:YAG laser because its HAZ is generally wider. This wider HAZ creates larger melt pools that tend to fill voids and burn off contaminants more effectively than an Nd:YAG laser.

Brazing is sometimes used to join surgical tools. It provides excellent gap filling and yields quality fillets in various applications, including joining bar stock to thin sheet metal. The sheet metal may be redesigned to include a pierced and extruded hole for the rod. The sheet metal part may also be fabricated of bar stock and machined to allow for a thick section where it is joined to the bar stock. This makes the design better for laser welding (see Figure 2).

Thin-metal welding can be improved by adding a sacrificial plate to form a sandwich construction (see Figure 3). This can prevent burn-throughs and wrinkling of the metal.

Finishing

In general, metal should be left near the weld zone so that it can be pushed into the welded recast zone. This helps filling and also eliminates depressions.

Burrs and sharp edges are best left to the machining process unless they interfere with fit-up. All machinists are trained to remove burrs routinely -a pervasive problem for laser welding. It is important to remember that not all burrs are bad. Burrs or sharp edges that are adjacent to the weld zone can actively aid in the welding process. Figure 4 shows the importance of not

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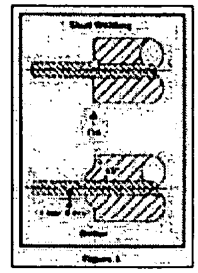
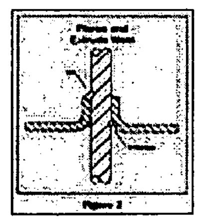
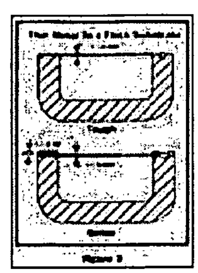


Pictured here are two joint designs for stud welding. The design on the bottom illustrates how the proper joint design can make a difficult material easier to weld.



When brazing a piece of bar stock to sheet metal, a pierce and extrude design can be used.



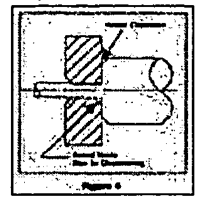
Shown here is a method for welding thin metal, in which a plate is chamfering weld joints.

Most medical welds are inspected under 10x magnification. No cracks should be visible at this power. In addition, hole depressions must have bottoms that are visible or they will be rejected. The reason for this is that depressions can become traps for contamination and cannot be cleaned easily.

Summary

Laser welding offers many advantages compared with other joining methods because of its accuracy, controllability, and small HAZ. Although laser welding can be costly, in some medical applications it is the only method that can achieve the desired results.

added to form a sandwich.



Avoiding chamfers prevents voids.